# Vapour Phase Catalytic Ammonia Removal (VPCAR)

## Background

The drive to design a new water purification system for Mars has arisen due to the vast differences between regular space missions to the International Space Station (ISS) and the long reach missions to Mars. Water is key to life, so there must be a constant source in order to maintain life on Mars. The main aspects for consideration are the following:

### Resupply

Long-range missions to Mars means that any components that have to be delivered will be classed as payload, that comes at a price of £1m per kg. There is an obvious financial incentive to reduce the amount of resupply that is required for the water to be purified.

### Maintenance

Unlike the ISS, a base on Mars will not be able to return to Earth in the event of an emergency situation. If anything breaks on the Mars base it could have potential fatal risks for those that are on site. Therefore all of the systems on a Mars base should ideally have an expected life span that is greater than any missions. In the case of long term habitation, the life span should be a long as reasonably possible, ensuring that if there is a problem there is time for a space flight to be arranged and to correct any problems.

### Modularity

A modular approach to crucial systems means that if there is a problem then the backups can be swapped in place, while repairs take place. Off-line repairs reduces the risk of failure of crucial systems.

### Heritage

For a technology to be used on a Mars base it will first have to fully tested on sites that are currently available. In real practice the establishment of a lunar base would be the best way to prepare for a long term Mars base, as this will allow an emergency return to Earth if the prototype equipment fails.

## VPCAR

With the previous considerations in mind this process has been developed for use on a Mars mission. This technology has been developed to produce potable water in a single step from a varying amount of wastewater streams; including grey water, urine and detergent based water.

### Process Description

The feed enters the VPCAR system and goes to the Wiped-Film Rotating Disk (WFRD). This is the core of the process, and it is responsible for removing inorganic salts and non-volatile organic contaminates for the water stream. These contaminates are concentrated in the bleed stream and removed.

Light-weight organic molecules (such as ammonia) are volatised in the WFRD along with the aqueous product are removed by a high temperature catalytic reactor. This reactor produces CO2, H2O and N2O. The reactor properties are:

* Packed-bed vapour phase reactor
* Catalyst of 0.5% platinum on alumina pellets
* Operates at 250°C
* Can be integrated as a component of the WFRD

Second catalytic bed is introduced to convert N2O (which is produced from ammonia oxidation) to N2 and O­2. The properties of this reactor are:

* 0.5% ruthenium on alumina pellets catalyst
* Operation temperature of 450°C
* Small flowrate of product stream through this reactor

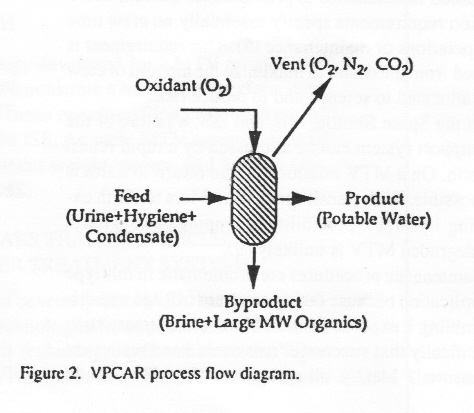
97% recovery rate is easily achievable, however if 100% recovery is required (as it will be) the bleed stream from the WFRD can be passed through a lyophilizer, aka freeze dryer.

Quantified comparison against the ISS:

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| --- | --- | --- |
|  | ISS | VPCAR |
| Equipment resupply | 467 kg/year | 0 kg/year |
| No. independent processors | 3 | 1 |
| Feed streams | 2 | 1 |
| ORUs | 12 | 1 |
| Weight | 437 kg | 227 kg |
| Volume | 2 ISS racks | 1 ISS racks |
| Power | 80 Wh/kg | 300 Wh/kg |
| Oxidant feed | 2 g/hr | >30 g/hr |
| Recovery rate | 99% | 97% (100%) |
| Scheduled maintenance | Every 50 days | 0 |
| Tech. Readiness Level | Level 6 | Level 4 |
| Design Life | 10 years | 5 years |

## Flowcharts of the process

### Basic System



## In depth flowchart

